Space Weather Technical Forecast

Issued on Monday, 04 September 2023 at 13:14 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: A chance of further isolated M-class flares through day 1 (04 Sep), becoming a slight chance going forward. A slight chance of G1/Minor Storm conditions day 1 (04 Sep) into day 2 (05 Sep).

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Low activity with a number of C-class flares over the past 24hrs. These have mainly come from the AR3413 sunspot region that has rotated off the visible disc, with the most recent long period C-class flare from this region peaking at C6.6 at 04/1107 UTC. Other C-class flares have come from sunspot regions on the visible disc, most commonly from AR3421.

Eight sunspot regions are present on the visible disc. AR3421 has shown the most growth and some activity, with some complexity in the magnetic configuration leading it to be classified as a Dsi/beta-Gamma. Magnetic looping has increased across this sunspot region also, as seen on SDO/AIA 171 imagery, so this area is one to keep an eye on. Elsewhere on the disc, most regions have remained stable or are showing some signs of decay with only a couple of new areas of growth. An area in the northeast has been numbered AR3422 and has seen some new spots develop. Another region (recently numbered as AR3423) has emerged coming around the northeastern limb from an area of plage, which may show more complexity as it rotates around further onto the visible disc.

CMEs associated with numerous flares from AR3413 in the past 24/36 hours are missing ahead of Earth orbit. A filament disruption that took place around 03/0500 UTC in the vicinity of AR3420 resulted in a slow, southward directed CME and has been modelled as a near miss. A filament lift-off occurred around 03/1930 UTC, again from an area close to AR3420 as well a small filament located around N20W00 around 03/2100 UTC. No CMEs have been observed from either of those two regions on SDO imagery, with the area near to AR3420 showing some material being re-absorbed.

Solar Wind / Geomagnetic Activity: Ongoing fast winds from CH40/+ slowly declined through the start of the period, though likely included some limited influence from one or both of the CME arrivals that were forecast, before becoming steady. Slightly Elevated solar winds were observed (at DSCOVR) at first with speeds of 476km/s at 03/1459 UTC, with solar winds generally showing a decreasing trend, falling to around 410km/s by the end of the period, briefly dipping to Slow at times. Density was above average at first with a peak of near 13pppc by 03/1321 UTC before dropping back to average, and then below average, levels through the rest of the period. Total Interplanetary Magnetic Field (IMF), Bt, was largely Weak, generally varying between 5-8nT. A minor, but abrupt increase was observed at 03/1550 UTC, perhaps indicative of a weak CME shock. The north-south direction, Bz, was predominately negative (southward) at first, briefly becoming positive from 03/1821 UTC before returning back negative. More recently is has become fairly neutral. Bz ranged between +3 nT and -4nT. Phi angle was positive (away from the Sun) between 03/1240-04/0030 UTC, then becoming more variable and fairly neutral. Geomagnetic activity has been mostly Unsettled (Kp3), but with some Quiet intervals from

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03/1800 UTC onwards.

Energetic Particles / Solar Radiation: GOES16 high energy (greater than 10MeV) proton flux has been at background levels throughout. GOES16 high energy (greater than 2MeV) electron flux was at background to Moderate levels, with a peak of 837 pfu at 03/01450 UTC. The associated 24-hour fluence was below the Active threshold, but on an increasing trend, with 1.92e7 integrated pfu observed at 04/0000 UTC.

Four-Day Space Weather Forecast Summary

Solar Activity: A chance of further Moderate activity through the period, with isolated M-flares possible, most likely from AR3421 which is currently showing the most complexity.

Solar Wind / Geomagnetic Activity: Solar winds under the influence of the fast wind from CH40/+ should continue on day 1 (04 Sep) before CH42/+ likely increases speeds to Elevated once again into day 2 (05 Sep). This is one of a few fast wind influences that could occur through the period with enhanced winds continuing throughout. There is a slight chance of a glancing impact from a CME on day 2. Mainly mainly Quiet to Unsettled (Kp0-3) at first on day 1 (04 Sep), but likely increasing to Unsettled or Active (Kp3-4) again later in the UTC day or into day 2 (05 Sep), with a slight chance of G1 Minor Storm (Kp5) intervals. Activity through the rest of the period is likely to vary mainly between Quiet and Unsettled, but with a slight chance of isolated G1 Minor Storm intervals.

Energetic Particles / Solar Radiation: High energy (greater than 10 MeV) proton flux is expected to continue at normal background levels, but with a slight chance for a Minor proton storm (S1) on day 1 (04 Sep), in association with any further notable flares from AR3413 that has just rotated over the northwest limb. As this area rotates further around the far side by day 2 (05 Sep) the risk is much reduced. High energy (greater than 2 MeV) electron flux observed by GOES16 is currently at background to Moderate levels. A recent response following the easing of the solar wind pressure means that occasionally Moderate to High levels are likely on day 1 (04 Sep) ahead of the arrival of the fast wind from CH42/+. Electron flux should drop to background to Moderate levels on days 2 and 3 (05 and 06 Sep), before a chance of becoming Moderate to High on day 4 (07 Sep). The associated 24 hour fluence is expected be below the Active (1e8 integrated pfu) threshold day 1 (04 Sep), but with a chance of rising above this level. Fluence should drop on days 2 and 3 (05 and 06 Sep) given increased geomagnetic activity, but may increase again on day 4 (07 Sep) with a chance of exceeding the Active threshold.

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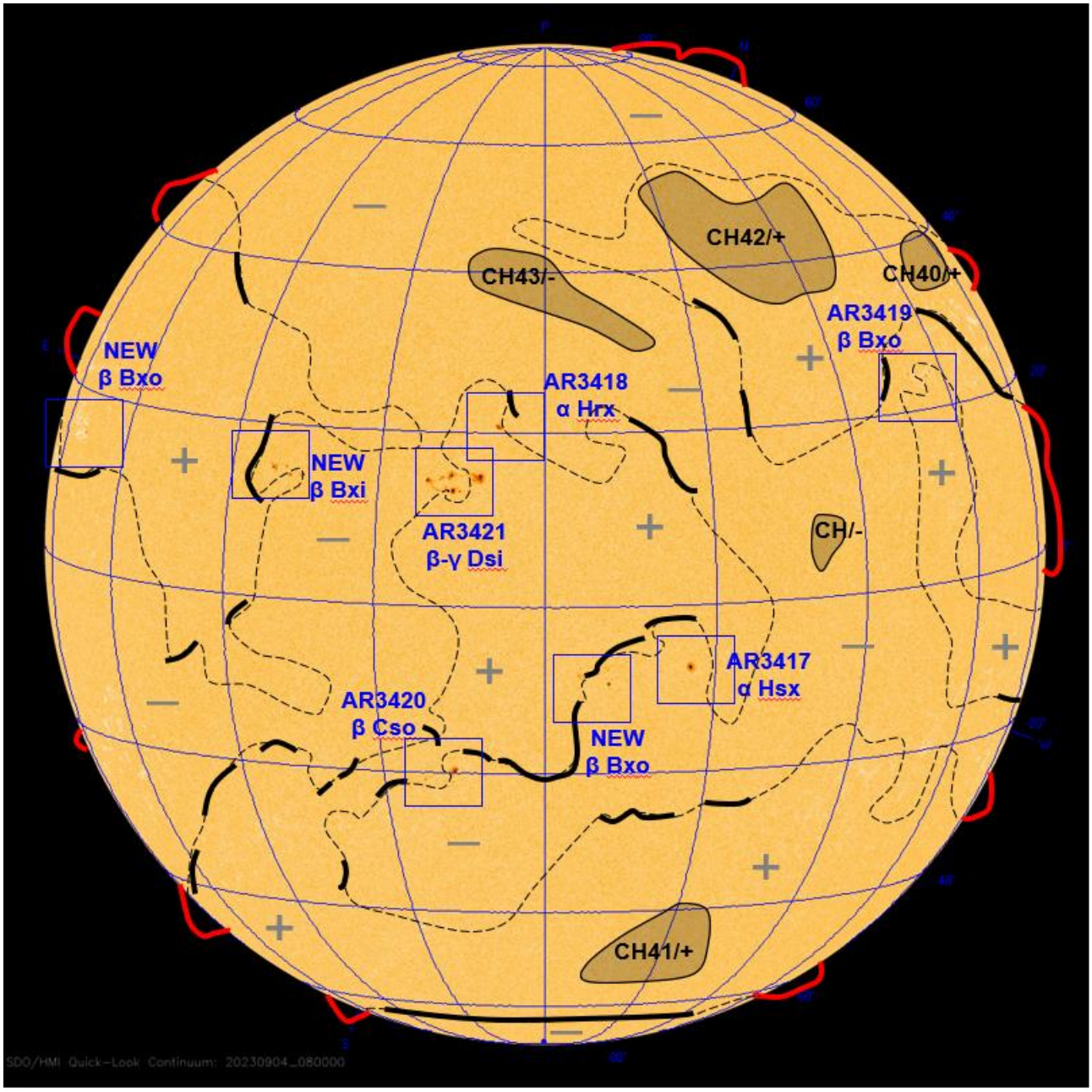
Figure 1. Solar Analysis Valid 04/0800 UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:
Earth is currently under the weakening influence of a coronal hole high speed stream (CH40/+), as well as some residual CME effects from the past 24/36 hours.
A large CME that left the sun early on 01 Sep appears to have already glanced Earth on 03 Sep, arriving around 03/1550 UTC at DSCOVR. Another CME that left the sun late on 01 Sep has been analysed as missing Earth behind Earth-orbit, but with a low confidence fit to imagery and analysis, there is a slight chance of a glancing impact on day 2 (05 Sep).

CMEs associated with numerous flares from AR3413 in the past 24/36 hours are missing ahead of Earth orbit. A filament disruption that took place around 03/0500 UTC in the vicinity of AR3420 resulted in a slow, southward directed CME and has been modelled as a near miss around day 4 (07 Sep) or beyond. A filament lift-off occurred around 03/1930 UTC, again from an area close to AR3420 as well a small filament located around N20W00 around 03/2100 UTC. Looking at SDO imagery there does not appear to be any evidence of CMEs from either, with material around the AR3420 region looking like it was somewhat reabsorbed.
Current Slightly Elevated winds from CH40/+ are expected to remain similar at first until the expected arrival of the next the fast wind of CH42/+ later on day 1 (04 Sep) and into day 2 (05 Sep), likely leading to Elevated solar winds again. These could persist throughout the period with numerous other high-speed streams moving into favourable locations to connect with Earth according to the Parker Spiral.

Activity mainly Quiet to Unsettled at first on day 1 (04 Sep), but likely increasing to Unsettled or Active again later in the UTC day or into day 2 (05 Sep), with a slight chance of G1 Minor Storm intervals. Activity through the rest of the period is likely to vary mainly between Quiet and Unsettled, but with a slight chance of isolated G1 Minor Storm intervals.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	20	20	10	10
Strong	G3	No	1	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections – Nil expected

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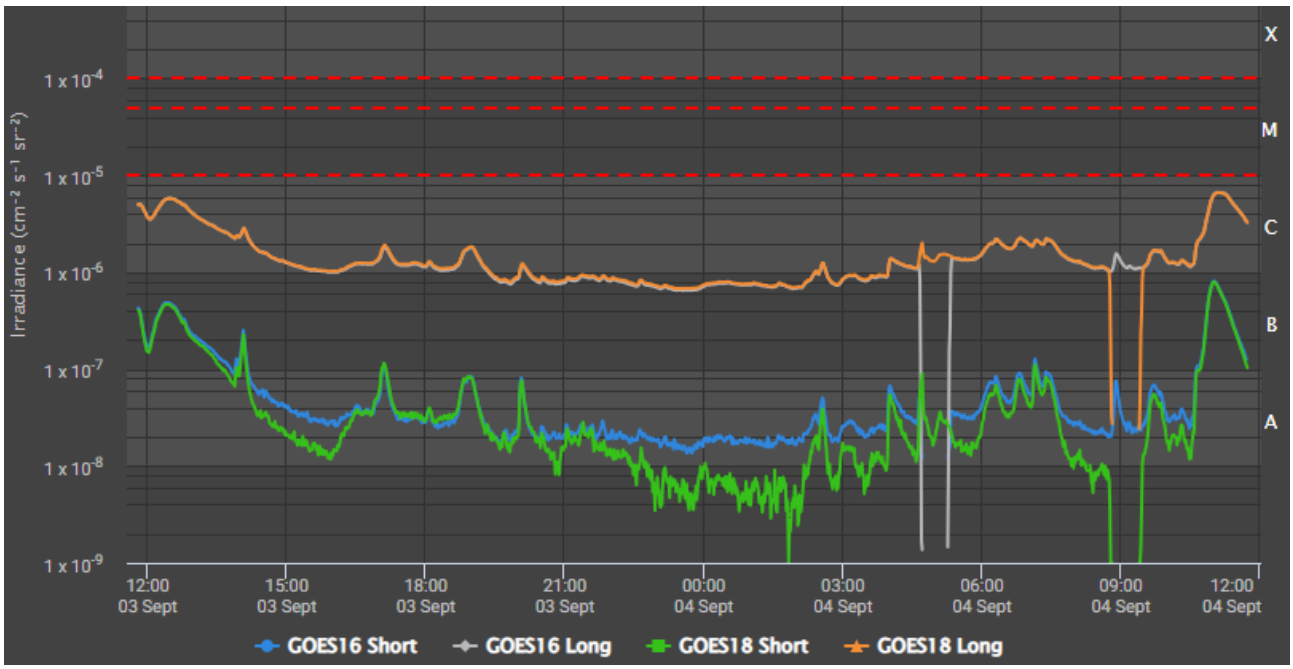
Radio Blackouts - X-Ray Flares:
Activity is Low as AR3413, which is now over the northwest limb, continues to move away from the visible disc. This region has been the source of recent significant activity, including multiple M- and C-flares over the weekend. Whilst its magnetic canopy remains visible above the limb it will continue to provide a chance of activity on day 1 (04 Sep), diminishing to become nil by day 2 (05 Sep). The chance of M-flares then looks more likely to be from regions on the visible disc, most notably AR3421.

Eight sunspot regions are present on the visible disc. The region AR3421 has shown the most development and complexity (currently classified as Dsi/Beta-Gamma), with an increase in magnetic looping around the region visible on SDO/AIA 171 imagery as well as trailing spots gaining size and forming rudimentary penumbra. There has been slow development of a few other regions, namely two newly numbered regions in the northeast (AR3422 Bxi//Beta and AR3423 Bxo/Beta). Elsewhere on the disc the sunspot regions are mostly small and inactive.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	No	25	20	20	20
Very Active	R3 to R5 X Class	No	2	1	1	1

Figure 2: X-ray flux over the past 24 hrs.



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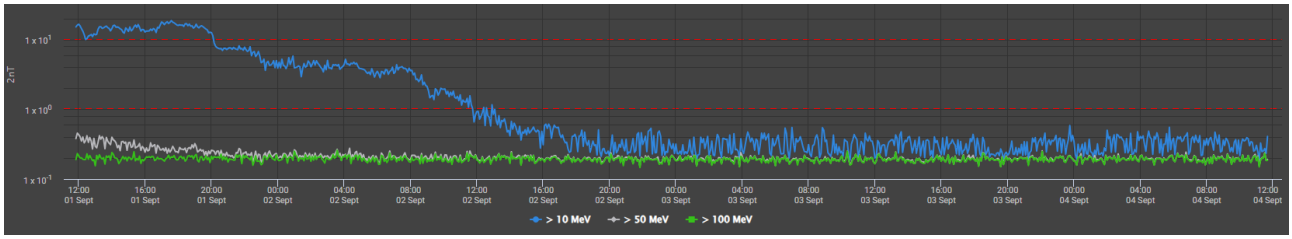
Solar Radiation Storms - (High Energy Protons):
The high energy (greater than 10MeV) proton flux observed by GOES-16 has now eased to background levels again after the S1 enhancement on 01 Sep. There is a slight chance for a Minor proton storm (S1) on day 1 (04 Sep) in association with any notable flares from AR3413 that has rotated over the northwest limb. This risk then recedes day 2 (05 Sep) onward with this sunspot moving further onto the far-side and with the other regions on the disc currently smaller and simpler.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	10	2	2	2
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

Figure 3: Proton flux over the past 3 days.



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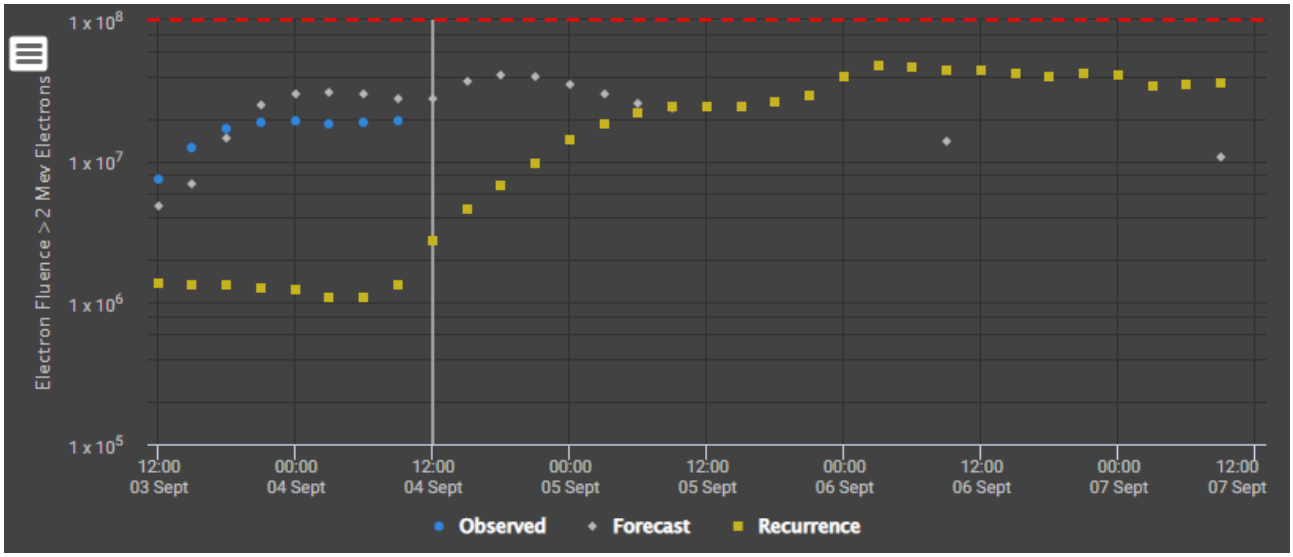
High Energy Electrons Event (≥ 2MeV):
High energy (greater than 2 MeV) electron flux observed by GOES16 is currently at background to Moderate levels. A recent response following the easing of the solar wind pressure means that occasionally Moderate to High levels are likely on day 1 (04 Sep) ahead of the arrival of the fast wind from CH42/+.

With numerous high-speed stream influences in the forecast period, it should lead to periods of drop out, along with subsequent enhancements in the following days, however this detail currently remains uncertain.

The associated 24 hour fluence is likely be below the Active (1e8 integrated pfu) threshold day 1 (04 Sep), but with a chance of rising above this level. Fluence should drop on days 2 and 3 (05 and 06 Sep) given forecast increased geomagnetic activity, but may increase again on day 4 (07 Sep) with a chance of exceeding the Active threshold if pressure on the Van Allen belts reduces as anticipated.

GEO Electron Environment Probability (Exceedance)	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ 2 MeV ≥ $1x10^8$**	No	30	20	20	40
Very Active	**≥ 2 MeV ≥ $1x10^9$**	No	1	1	1	1

Figure 4: REFM showing observed, forecast and recurrance electron fluence.



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